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ABSTRACT

Research was conducted to compare evidence of implicit processing in children and adults. Implicit processing was defined as inductive cognitive activities which enable people to abstract complex knowledge from the environment. The knowledge acquired is tacit; it guides subjects' behavior in various situations without the subjects necessarily being aware of the nature of this knowledge. The first part of the study involved 27 subjects ranging in age from 5 to 60 years, while the second part included 115 children from three age groups: 5-7, 9-11, and 12-14. In the first part of the experiment (the acquisition phase), subjects were asked to reproduce from memory sequences of simple geometric shapes whose order was determined by a complex rule system (grammar). In the second part (the testing phase) the subjects were asked to recognize these sequences from a set of instances that included three types of sequences: the familiar grammatical sequences that the subject had reproduced in part one, new grammatical sequences that were generated from the same grammar, and nongrammatical sequences that were generated by violating the grammar. Significant age differences were found in the first part of the experiment, but not in the second part. In both studies younger children performed as well as older children and adult subjects. All subjects had a harder time distinguishing between old and new sequences generated from the grammar as compared to sequences generated by violating the grammar. Therefore all the subjects exhibited some degree of abstraction of the underlying grammar. (HOD)

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UNCONSCIOUS ABSTRACTION PROCESSES:

CAN CHILDREN PROCESS AS WELL AS ADULTS?

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Unconscious abstraction processes:

Can children process as well as adults?

When I was informed that my paper would be presented in a session titled: 'perceptual and conceptual development', I was delighted with this choice. The reason is that I think the research I have recently completed, should indeed be viewed within the context of the relation between perceptual and conceptual knowledge. More specifically, it raises the possibility that unconscious abstraction processes are activated during interactions with the external, physical world and in addition that these processes are independent, to a certain extent, of the conceptual and operatory level of development of the individual.

The present study touches upon two interrelated topics which are usually addressed separately within Piagetian research and theory. The first is the relationship between knowledge of the object and conceptual development; the second is the role of unconscious and conscious cognition. Each topic in itself is too complicated to be explicated in a short presentation. Therefore, I will only suggest in very broad strokes the relationship between these two topics and proceed from there directly to the study and its results.

Piaget emphatically rejects two extreme positions which he calls: empircist and nativist. According to the 'empircist' view perceptual development and knowledge is sufficient to explain conceptual development. In other words, conceptual knowledge is derived directly from perception. In contrast, according to the 'nativist' position,

perceptual knowledge plays only a minor role in concept formation, hence specific interactions with an environment are not necessary in forming basic concepts.

Piaget alternative is an interactional and constructivist model whereby perceptual information and more precisely perceptual activity is necessary for concept formation. Yet intelligence is not derived from the perceptual system (e.g. Piaget & Inhelder, 1969, p. 44). The relationship between the knowing subject and the object to be known is one of interdependence. "It is impossible to dissociate the 'knowing subject' from the 'knowable object'." (Inhelder, Sinclair & Bovet, 1974, p. 6). In other words, by a process which Piaget calls "simple" abstraction the subject extracts information from the object itself, but what the subject notices in the object depends on how he can relate the information to his own logical activities. Therefore there is a dependence on the subject's cognitive development. I will suggest that in addition to simple abstraction there exist an additional variety of abstraction processes, an unconscious abstraction process which is more independent of the subject's cognitive level and therefore more open and sensitive to the underlying invariances and regularities of the physical enviornment. This leads directly to the second issue - the role of consciousness.

Piaget, in his more recent works, addresses the issue of the cognitive unconscious and the role of cognizance, or coming into

consciouness (Piaget, 1973; 1976). According to Piaget (1973), there are two levels of knowing - the unconscious and the conscious. Cognizance, coming into awareness is not, as some psychologist may claim, merely an illumination of the obscure. Awareness requires a reorganization, a reconstruction of that which is already organized in another manner on a lower level. As Piaget repeatedly states (Piaget, 1976, p. 332 for example) the processes of cognizance, the act of becoming conscious, is a reconstructive activity and is a process of conceptualization.

Piaget has presented a series of empirical studies which demonstrate that there is a lag between the child's successful actions and conscious knowledge of these actions. Subjects initially exhibit an unconscious, sensorimotor, understanding of the tasks. This tacit understanding can guide their behavior and problem solving but does not, in itself, enable a conceptual or operational level of functioning. Only through additional construction and interaction is such a level achieved.

The proposition I would like to put forth is that incorporated within unconscious cognitive functioning are processes that abstract underlying regularities, patterns and invariances in the environment. These processes function at a very primitve level and are, to a certain extent, independent of the operatory level of the individual. The utilization of the tacit knowledge abstracted with these processes, as well as the role of the tacit knowledge in conception, is always

dependent on and modulated by the existing cognitive structures. The purpose of such processes, the conditions for their activation and perhaps even the question of their very existence is both a theoretical and an empirical issue. I will present some empirical evidence for the existence of such processes.

The present research was designed to study implicit processing in in children. Implicit processes are inductive cognitive activities which enable humans to abstract complex knowledge from the environment. The knowledge aquired with these processes is tacit; that is, it guides the subjects' behavior in various situations without the subject being necessarily aware of the nature of this knowledge and, often, of its very existence.

In order to study these processes experimentally three conditions must be met: (1) The subjects must be attending actively to the instances generated by an underlying rule system. In other words, the subject must be actively interacting with the object. (2) The rule system that generates the instances must be complex in the sense that any explicit analytical process that the subjects might possibly employ (such as hypothesis testing or logical analysis) would be inadequate for discovering the rule system. In other words, the underlying regularities are extraneous to the subject's existing cognitive schemes. (3) The tasks for testing whether these processes are activated should be sensitive to the existence of acquired knowledge of the underlying

invariance, without requiring the subject to explicate or verbalize this knowledge in any way.

Evidence for the existence of implicit processes has been found in a number of studies conducted by Reber and his associates over the past twenty years (Reber, 1967; 1969; 1976; Reber & Allen, 1978). All of these studies were carried out with adult populations. The current studies investigate implicit processing of underlying complex rule systems (grammars) by children using an experimental paradigm that is similar to the one used by Reber in his research.

It was hypothesized that if children were exposed to the same type of tasks that were used by Reber and his associates, these children would abstract the complex underlying invariances as well as adult subjects. This knowledge should be manifested in the subject's recognition scores. If the subjects had indeed abstracted the underlying grammar then the subjects should find it difficult to reject novel grammatical instances, while successfully recognizing old grammatical instances and rejecting nongrammatical instances.

In order to test these predictions two studies were carried out. The first was with 27 subjects ranging in age from five to sixty years old. The second study included 115 children from three age groups: 5 - 7, 9 - 11 and 12 - 14. The experiments were conducted in two parts. In the first part (the acquisition phase), subjects were asked to reproduce from memory sequences of simple geometric shapes whose order was

determined by a complex rule system (grammar). See Figure 1 for a schematic representation of the finite-state grammar used and Figure 2 for examples of the instances such a grammar generates. In the second part of the experiments (the testing phase), the subjects were asked to recognize these sequences from a set of instances that included three types of sequences: (1) OLDG - the familiar grammatical sequences that the subject had reproduced in Part I; (2) NEWG - new grammatical sequences that were generated from the same grammar; (3) NONG - nongrammatical sequences that were generated by violating the grammar either once or twice.

In the first part of the experiment - the learning phase - significant age differences were found (see Table 1 and 2). There were no significant age differences found in the second part of the experiment - the recognition part. In both studies younger children performed as well as older children and adult subjects. All subjects had a harder time distinguishing between old and new sequences generated from the grammar as compared to sequences generated by violating the grammar (see Table 3 and 4). Therefore all the subjects clearly exhibited some degree of abstraction of the underlying grammar. In order to test if the subjects really acquired any abstract knowledge of the underlying rule system, in one condition of the second study, subjects were exposed to randomly generated sequencess. Their performance was markedly different from the performance of the subjects in the structured conditions (see Table 5).

The research findings suggest that: (1) Young children have the ability to implicitly abstract complex underlying invariances. (2) Implicit processes remain available in their rudimentary form to adults. and (3) It is possible that these processes are activated in situations where formal operational knowledge is not called forth or ineffectual.

The study of implicit processes is only in its infancy and there are more open questions than answers. A great deal of additional research is necessary.

Does this type of research and results have any implications for Piagetian theory and our understanding of conceptual development? I suggest that these results should not be dismissed by Piagetians, nor are these results incompatible with a constructionist view of concept formation. Piagetian theory, or any other developmental theory must deal with two fundamental issues: adaptation to a changing and hetrogeneous environment and creation of new concepts and ideas. One factor and source for creativity, as well as adaptivity, is our seeming ability to 'pick up' underlying invariances and regularities in the environment without the influence of, or in addition to, the influence of existing operative thought and structures. Conceptualization, on the other hand, is a completely different process. It involves (amongst other) construction and integration of that which is tacitly known through implicit processing into coherent, reversible, potentially explicable

and therefore conceptual knowledge. In our efforts to understand the advance stages in conceptualization we must not overlook some of the possible preliminary stages in our acquisition of knowledge. Implicit processing of the underlying invariances that exist in the enviornment may play an important role at the initial stage of concept formation and this possiblity should be explored.

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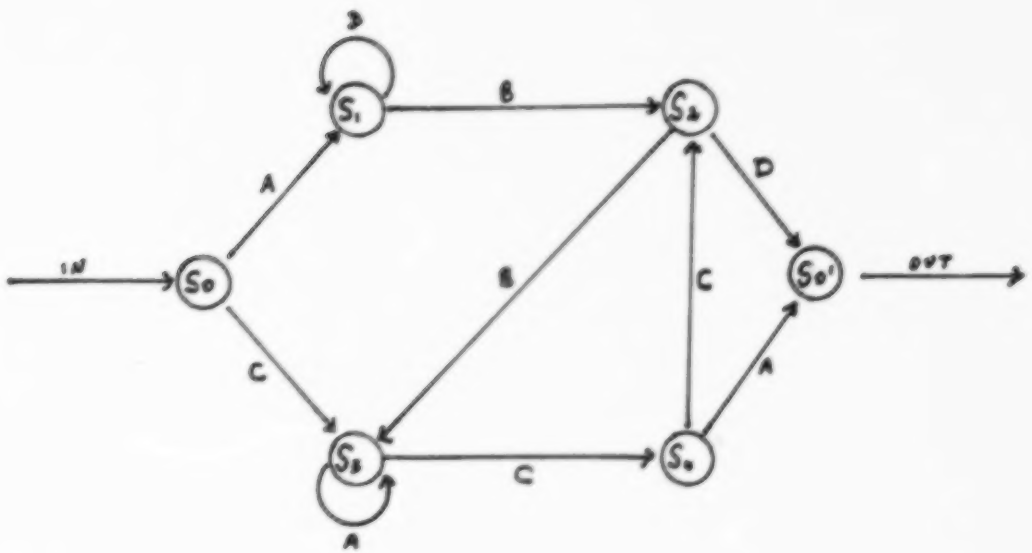
Figure 1

Schematic diagram of the finite-state grammar

used to generate the sequences



Simple Stimuli		Meaningful Stimuli	
A =	yellow	A =	yellow
B =	blue	B =	blue
C =	green	C =	green
d =	red	D =	red

Figure 2

All possible sequences of lengths of 3 to 7 shapes generated from the finite state grammar shown in Figure 1 and their distribution in Experiment 1 and Experiment 2

Exper. 1*	Exper. 2*		Exper. 1*	Exper. 2*	
B	B	△□○	A	A	△□□△◇△
C	C	◇◇△	B	B	△○□□◇△
			B	B	△○○○□○
A	A	△○□○	C	C	△□□◇◇○
B	B	◇△◇△	-	C	◇△△△◇△
C	C	◇◇◇○	C	C	◇◇◇□◇△
			A	B	◇△△◇◇○
A	A	△□□◇△			
-	B	△○○□○	A	A	△○○○○□○
B	A	◇△△◇△	-	-	△○○□□◇△
C	C	◇△◇◇○	A	C	△○□□△◇△
			B	B	△□□△△◇△
			B	B	△○□□◇◇○
			C	C	△□□△◇◇○
			C	C	◇△△△△◇△
			A	B	◇◇◇□◇◇○
			B	B	◇△◇◇□◇△
			-	-	◇◇◇□△◇△
			c	c	◇△△△◇◇○

* Distribution of sequences in part I and part II of each experiment.

A - Used in part I of the experiment.
B - Used in part II of the experiment.
C - Used in both parts of the experiment.
- - Not used.

Table 1

Mean Number of total trials to reproduce 15 sequences correctly - by age and repetition

Experiment 1

N=27

Group	Repetition		
	1st time	2nd time	1st&2nd
5 - 7	29.00	26.20	27.60
9 - 10	22.30	21.30	21.80
Adults	19.87	18.71	19.29
Mean	24.15	22.44	23.30

Effect of Age: $F(2,24)=11.15$, $p<0.001$

Table 2

Mean total trials to reproduce 15 sequences correctly - by age and condition

Experiment 2

N=117

Age	Condition ImS	ImM	ExS	R	Mean Age
5 - 7	34.30	26.90	30.70	33.90	31.95
9 - 11	21.30	21.50	21.75	24.59	22.28
12 - 14	18.60	17.97	19.83	24.59	19.02
Mean Condition	24.73	22.79	24.09	26.06	

Effect of Age: $F(2,93)=80.57$, $p<0.0001$.

Table 3

Mean percent correct recognition

by age and type of sequence

Experiment 1

N=27

Type of sequence	Age Group 5 - 7	9 - 10	Adults
OLDG	67.70	67.70	77.00
NEWG	57.20	51.60	37.00
NONG1	71.57	73.00	69.29
NONG2	86.40	87.00	83.57
Mean	70.70	70.03	66.77

Effect of Age: $F(2,24)=0.38$, $p=0.69$

Effect of Type of Sequence: Wilkens Lambada $p<0.0001$

Paired comparisons:
OLDG vs. NEWG: $F(1,24)=16.85$, $p<0.001$
NEWG vs. NONG1: $F(1,24)=11.62$, $p<0.01$
NONG1 vs. NONG2: $F(1,24)=28.02$, $p<0.001$

Table 4

Mean percent of correct recognition - by age, condition and type of sequence

Experiment 2

N=115

Age	Type of sequence	Condition ImS	ImM	ExS	R	Mean
	OLDG	61.00	53.00	56.00	59.00	57.30
5 - 7	NEWG	57.00	68.00	59.00	63.00	61.80
	NONG	81.00	87.00	80.00	54.00	75.50
Mean	5 - 7	66.30	69.30	65.00	58.70	64.80
	OLDG	60.00	56.00	65.00	57.00	59.50
9 - 11	NEWG	50.00	63.00	50.00	65.00	57.00
	NONG	79.00	88.00	90.50	58.00	78.80
Mean	9 - 11	63.00	69.00	68.30	60.00	65.10
	OLDG	66.00	63.00	59.50	64.10	63.00
12 - 14	NEWG	61.00	72.70	53.33	71.00	64.50
	NONG	88.00	94.30	85.30	66.00	83.40
Mean	12 -14	71.70	76.80	66.00	66.70	70.30
Mean Condition		67.00	71.70	66.40	61.80	

Effect of Age: $F(2,91)=2.86$, $p>0.06$

Effect of Type of Sequence: $F(2,91)=86.61$, $p<0.0001$.

Table 5

Mean percent correct recognition of the three types of sequences: ImS, R and Structured* conditions

Experiment 2

Type of sequence	Condition ImS N=30	Structured* N=85	R N=30
OLDG	62.30	59.30	60.00
NEWG	56.00	60.50	66.30
NONG	82.70	86.10	59.30
Mean	67.00	68.60	61.90

* Structured = $\frac{\text{ImS + ImM + ExS}}{3}$

Planned comparisons

ImS: OLDG vs. NEWG - $F(1,48)=1.16$, $p=0.29$
NEWG vs. NONG - $F(1,48)=87.37$, $p<0.0001$

R: OLDR vs. NEWR - $F(1,48)=5.47$, $p<0.05$
NEWR vs. NONR - $F(1,48)=6.02$, $p<0.01$

ImS vs. R: OLDG(R) - $F(1,48)=0.29$, $p=0.66$
NEWG(R) - $F(1,48)=3.72$, $p=0.056$
NONG(R) - $F(1,48)=31.11$, $p<0.0001$

Structured vs. R: OLG(R) - $F(1,103)=0.01$, $p=0.88$
NEWG(R) - $F(1,103)=1.60$, $p=0.21$
NONG(R) - $F(1,103)=58.40$, $p<0.0001$